HABITATS OF SELECTED BUTTERCUPS WITHIN THE *RANUNCULUS OCCIDENTALIS* COMPLEX (RANUNCULACEAE)

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ABSTRACT

Habitat characterization can be helpful in assigning questionable populations to a specific taxon when distinguishing morphological characteristics are obscure or debated by authorities. Such a classification problem arises in the case of the autumn buttercup, *Ranunculus aestivalis* (Benson) Van Buren and Harper. This problem has special significance since the taxon is listed as endangered (*R. acriformis* var. *aestivalis*). This paper describes and compares habitats associated with the autumn buttercup and selected relatives within the *R. occidentalis* complex and with adventive populations of *R. acris* in Utah. Two populations of *R. occidentalis* (Nevada County, California), 3 populations of *R. acriformis* var. *acriformis* (Emery and Sanpete counties, Utah), 3 populations of *R. acriformis* var. *montanensis* (Lincoln County, Wyoming), 3 populations of *R. acris* (introduced from Europe and now growing wild in Rich and Cache counties, Utah) and 2 populations of the endangered species, *R. aestivalis* (endemic to Garfield County, Utah) were sampled. Analysis of vegetal and physical environments as well as tissue chemistry associated with these taxa show that they can be separated on the basis of habitat characteristics and/or tissue chemistry. Populations of *R. occidentalis* and *R. aestivalis* are widely separated from other taxa in principal components diagrams, whereas the two varieties of *R. acriformis* occur close together in statistical space. *Ranunculus acris* populations were broadly scattered in the diagrams. Characteristics of habitats associated with these taxa differ in many ways. These results parallel those of our previous molecular study involving the same taxa and support elevation of the autumn buttercup to species level. The study provides information about the habitat of the autumn buttercup that should be useful to managers responsible for its recovery.

The autumn buttercup, *Ranunculus aestivalis* (Benson) Van Buren and Harper, is a federally listed endangered species assigned by Benson (1948) to the *R. occidentalis* group in the Section *Chrysanthe*. The group includes taxa that extend southward from the northern Yukon Territory to mountains and valleys throughout northwestern United States. The majority of species and varieties within the *R. occidentalis* group are located in the Pacific-Sierra region and the northern Rocky Mountains. Satellite species extend eastward and southward into Utah. All taxa in the *R. occidentalis* group share common morphological characteristics and selected taxa within the group share numerous DNA markers (Van Buren et al. 1994). Phenetic relationships were determined (Van Buren et al. 1994) using DNA marker analysis, which provides an estimate of

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TABLE 1. LOCATIONS OF POPULATIONS OF THE FIVE *RANUNCULUS* TAXA CONSIDERED.

Taxa	No. populations	County (s)	State	Elevation (m)
Ranunculus occidentalis var. *ultramontanus* (ROCU)	2	Nevada; Sierra	CA	1800
R. acriformis var. *montanensis* (RACM)	3	Lincoln	WY	2000–2450
R. acriformis var. *acriformis* (RACA)	3	Sanpete; Emery	UT	2500–2900
R. acris (RARS)	3	Rich; Cache	UT	1700–1900
R. aestivalis (RAES)	2*	Garfield	UT	1950

* A site occupied by plants in 1991 but without plants in 1992 was sampled for habitat characteristics.

genetic similarity to be expected among taxa belonging to various classification levels (i. e., species and varieties) within the section.

Ranunculus aestivalis, an endemic of the Sevier River drainage in southern Utah, has been variously treated by systematists. The taxon was described by Lyman Benson in 1948 and treated as a variety of *Ranunculus acriformis* (*R. acriformis* var. *aestivalis* Benson) in the *R. occidentalis* group. In 1986, Welsh made the autumn buttercup a variety of *R. acris* [*R. acris* var. *aestivalis* (L. Benson) Welsh], a European species otherwise recognized in North America as an adventive only. The taxon is treated as *R. acris* var. *aestivalis* in the most recent edition of A Utah Flora (Welsh et al. 1993) and is considered to be an indigenous entity. It is widely disjunct from its parent species which may reach the Aleutian Islands but does not enter North America (Welsh 1974). Unique problems arise when taxonomical disagreements involve an endangered species. The autumn buttercup was listed as an endangered plant by the United States Fish and Wildlife Service under the name *Ranunculus acriformis* var. *aestivalis* L. Benson (Federal Register 1989). Based upon molecular comparisons of genomic DNA of the autumn buttercup and close congeners, this taxon was recently elevated to the species level as *R. aestivalis* (Benson) Van Buren and Harper (Van Buren et al. 1994).

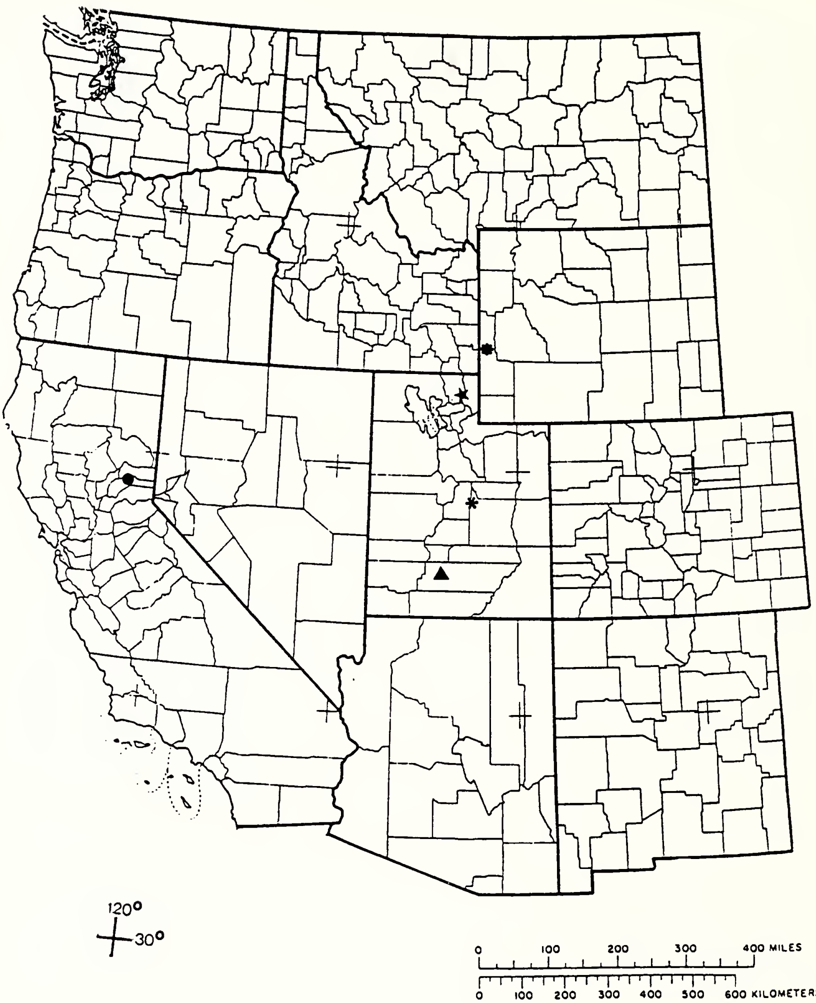
To provide additional data on the relationships of the autumn buttercup to close congeners in the West, we analyzed habitat data collected at selected sites of occurrence of four perennial taxa within the *R. occidentalis* complex, and at three *R. acris* sites. These are the same sites where the authors collected leaf tissue for DNA analyses (Van Buren et al. 1994). The sample includes taxa assigned to both species and varietal levels of classification (Table 1).

Andersson (1990) suggested that habitat characteristics should be considered when morphological characteristics do not permit unambiguous classification. Van Valen's (1976) ecological species concept defines species as lineages occupying minimally different adaptive zones. This idea suggests that it is the selective pressures of the environment that result in local maintenance of unique phenotypes. Habitat selection has not been widely discussed for plant species, and supportive data are scarce. Immobility, dependence on morphological and chemical defenses, and extreme competition for resources are a few attributes unique to plants that make them less capable of assertively selecting habitat. Perhaps a more defensible view is that the habitat selects for plants with specific phenotypic or physiological characteristics. Loveless and Hamrick (1984) review ecological factors influencing genetic characteristics of plant populations. The influence of environmental and community characteristics on success of various plant species in a given habitat is beyond argument. There is thus a need for information about the characteristics of habitats that support any given plant species.

The purpose of this paper is to describe habitat conditions associated with closely related buttercups, and to identify ecological factors that may distinguish habitats congeners occupy. Habitat requirements are of particular interest to those charged with recovery efforts for endangered plant species (Menges and Gawler 1986; Buchele et al. 1989; Nelson and Harper 1991; Davis and Sherman 1992; Young 1992). Thorough descriptions of abiotic and biotic attributes of endangered species habitats may be useful for selection of potential sites for introduction and expansion of a species' range and may aid in finding remnant populations.

Methods

Study sites. Habitat data were collected at 13 sites selected in connection with molecular (Van Buren et al. 1994) and morphological studies of these taxa (Table 1). All populations except those of *R. aestivalis* are separated by at least 1 km. On the date of collection of habitat data, all populations supported observable individuals except one site of *R. aestivalis.* However, abiotic data were collected from the site previously occupied by *R. aestivalis* which is about 0.5 km from the inhabited site. Figure 1 shows the general location of study sites for each taxon. Sites were moist, montane meadows in natural landscapes or in wet pastures in agriculturally developed areas. One population of *R. occidentalis* was located on moist, gravelly stream banks. All habitat sampling was completed during the month of July 1992. Voucher specimens of buttercups from each of the populations discussed are deposited at the Brigham Young University Herbarium, Provo, Utah (BRY), and the Arizona State University Herbarium, Tempe, Arizona (ASU).



● Ranunuculus occidentalis var. ultramontanus
✸ R. acriformis var. montanensis
∗ R. acriformis var. acriformis
★ R. acris
▲ R. aestivalis

FIG. 1. General locations of study sites of selected *Ranunculus* taxa.

Sampling. Soil samples were collected from each study site by inserting a 2.5-cm-diameter tube approximately 15 cm into the soil at various locations within 0.25 m^2/quadrats centered over each of 10 randomly selected buttercup plants. Soil subsamples from each site were combined and the composite samples were analyzed by the Brigham Young University Soil Laboratory, Department of Agronomy and Horticulture. Soil pH, texture (% sand, silt and clay), percent organic matter, available phosphorus concentrations, and electrical conductivity were determined using methods recommended by Black et al. (1965). The presence of free soil carbonates was estimated using 10% hydrochloric acid (U. S. Salinity Laboratory Staff 1954). Soil temperature was measured by inserting a 0.4 m long steel-stem soil-thermometer into the soil at 10 random points within each study site. Soil depth was estimated by pushing a sharpened, 1.0 m steel penetrometer (rod diameter = 1.0 cm) as far as possible into the soil at ten random points at each site. Vegetal data were collected in 0.25 m^2 nested frequency quadrats centered over 10 randomly selected buttercup plants, and at 10 randomly chosen locations that did not support a buttercup plant but were within the area sampled at each of the 13 study sites (Smith et al. 1987). Relative frequency and percent cover for shrub, forb, grass, and cryptogamic species were estimated using the nested frequency frame to which eight points had been attached for cover estimation. Maximum height of vegetation associated with the buttercup in each quadrat was recorded. Percent cover for rock, soil, and litter were estimated using the same device. Species richness (average number of species per quadrat) in each quadrat was also calculated for each study site.

Buttercup tissue analyses were based on living leaf, stem and flower tissue of 10 randomly selected, adult individuals at each study site. Sampled individuals were at similar phenological stages. All tissue from a site was combined, quickly air-dried, and ground to pass a 0.64 mm diameter sieve. Samples were analyzed for total P, K, Ca, Mg, Na, S and % ash at the Department of Agronomy and Horticulture Tissue Analysis Lab, Brigham Young University. Analytical methods were those of the Association of Official Analytical Chemists (Horowitz 1980).

Statistical analyses. Vegetative, abiotic, and tissue chemistry data were analyzed using centered, standardized principal components analysis (STATGRAPHICS 1993) in order to visualize the relationships of the taxa as separated by variables in each data set. Discriminant analysis was employed for the larger data set consisting of vegetative characteristics of quadrats that were occupied or unoccupied by buttercup plants of the several taxa (STATGRAPHICS 1993). This analysis identified probable factors distinguishing microsites occupied and unoccupied by buttercups. Discriminant analysis would have been informative for abiotic and tissue chemistry analyses had the sample sizes been larger. Unfortunately, the collection of additional samples was beyond the resources of this study and, in the case of *R. aestivalis,* not possible.

RESULTS

Figure 2A shows the values of the first two principal components for the 13 study sites occupied by populations of the five taxa. These components are based on the abiotic habitat data reported in Table 2. The two components account for over 66% of the variation existing in this data set. Populations of *R. acriformis* (both varieties), *R. aestivalis,* and *R. occidentalis* are separated into "distinct" conspecific groups in the figure, but populations of *R. acris* are widely separated in statistical space. *R. occidentalis* and *R. aestivalis* are widely separated on the first component axis. The varieties of *R. acriformis* clump closely together on the first component axis, but they separate somewhat on the second axis. Figure 2B shows the weighting of the abiotic habitat variables along the two component axes. This diagram provides information that may be useful for interpretation of Figure 2A. Vectors connecting each variable to the origin suggest how influential individual variables might be in separating the plant taxa along an axis: vectors that closely parallel an axis are strongly correlated with that axis and may be influential factors in the relative success of the plant taxa along the axis. For example, soil electrical conductivity, depth, organic matter and free carbonate content are well correlated with component axis 1 (their vectors are nearly parallel to the axis), and may be influential factors controlling the distribution of taxa widely separated on that axis. Soil temperature, on the other hand, is the environmental variable best correlated with component axis 2. Sand and P are probably less important as their vectors are less parallel to the axis. When these habitat factors are considered in relation to placement of the several taxa in Figure 2A, the *R. occidentalis* and *R. aestivalis* sites on the first component axis are best separated using soil depth, organic matter, free carbonates and electrical conductivity. On the second component axis, the *R. acriformis* varieties and *R. acris* are apparently separated by differences in soil temperature. Table 2 shows that soil temperature values for *R. acris* vary greatly among themselves (i.e., the SE-value is large relative to the mean; Fig. 2A).

Because populations of the taxa considered in this paper were widely separated in the West, associated species differed markedly from one taxon to another. Nevertheless, the general aspect of occupied habitats was similar for all of the taxa. Although vegetative characteristics were recorded by species in the field, the data have

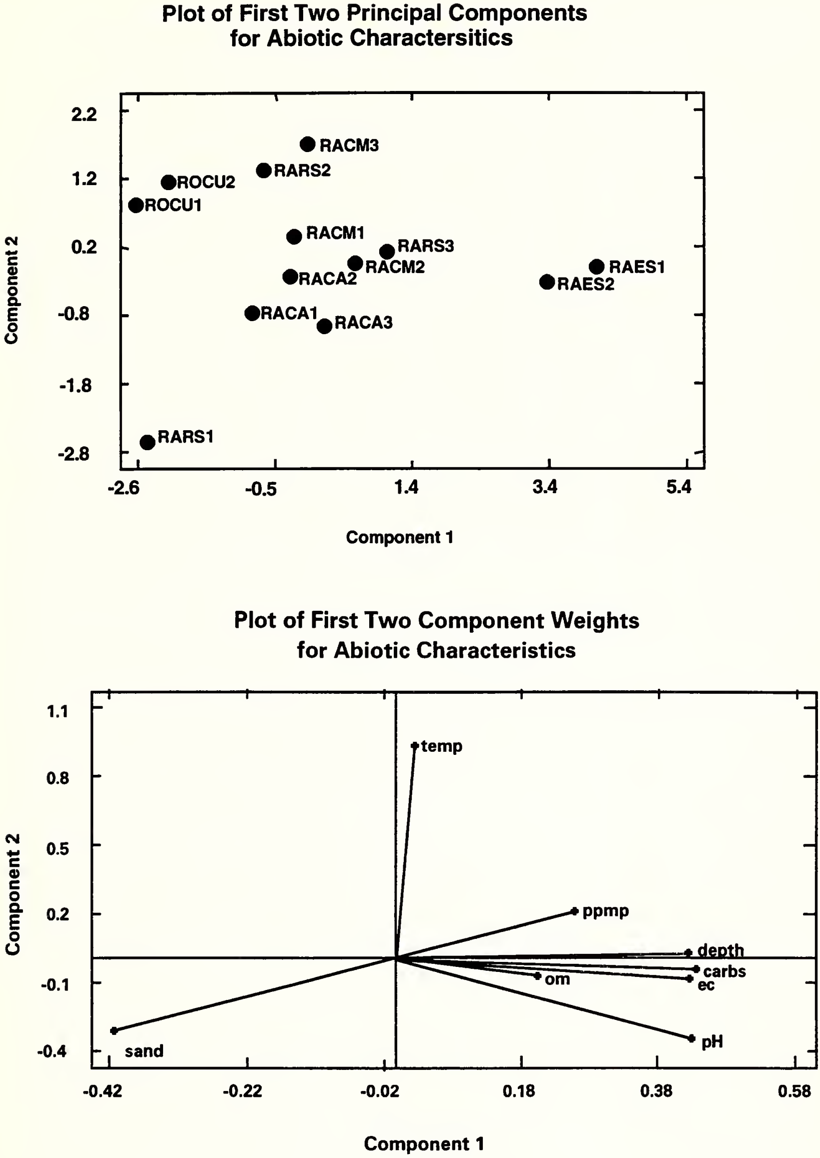


FIG. 2. A. Scattergram of the first two principal components for analysis of abiotic data collected from 13 study sites of selected *Ranunculus* taxa. Abbreviations for taxa as listed in Table 1. Populations are identified as numbers following the taxon abbreviation. B. Plot of weighting vectors for selected habitat variables on the first two principal component axes.

TABLE 2. COMPARISON OF MEAN VALUES OF HABITAT ABIOTIC CHARACTERISTICS FOR FIVE *RANUNCULUS* TAXA. Abbreviations for taxa are as in Table 1. Standard error for each mean is in parentheses.

	Taxa				
	RACA	RACM	RARS	ROCU	RAES
Soil pH	6.7 (0.15)	6.7 (0.21)	6.8 (0.25)	5.8 (0.20)	7.7 (0.19)
Soil temperature	12.6 (0.21)	15.7 (1.05)	13.7 (3.95)	18.0 (0.35)	14.4 (0.75)
Soil depth (dm)	5.7 (0.91)	3.7 (0.29)	2.5 (1.73)	3.2 (1.45)	10.0 (0)
Soil texture (% sand)	43.8 (3.94)	40.0 (63.61)	46.6 (10.52)	57.4 (6.15)	25.1 (0)
Organic matter (%)	7.8 (2.02)	8.1 (1.33)	5.1 (1.65)	3.2 (0.45)	12.3 (7.6)
Electrical conductivity (mmho/cm)	1.3 (0.49)	1.3 (0.07)	1.2 (0.23)	0.7 (0.05)	2.5 (0.78)
Free carbonates (arbitrary units)	0	0.2 (0.17)	0.7 (0.66)	0	2.5 (0.50)
Available phosphorus (ppm)	10.9 (1.9)	103 (34.2)	17.1 (1.96)	9.1 (2.8)	87.2 (1.25)
Sample size	3	3	3	2	2

TABLE 3. COMPARISON OF GROSS CHARACTERISTICS OF VEGETATIONAL ENVIRONMENTS ASSOCIATED WITH THE FIVE TAXA OF *RANUNCULUS* Considered. Standard error for each mean is shown in parentheses. Abbreviations for taxa are as in Table 1.

	Taxa				
Vegetative parameter	RACA	RACM	RARS	ROCU	RAES
Species Richness (No. species/0.25 m^2)	17.5 (1.33)	20.7 (1.80)	15.6 (2.42)	14.8 (1.84)	11.5 (3.7)
Grass Cover (%)	57.6 (9.01)	41.4 (9.64)	36.2 (12.59)	44.4 (18.03)	41.3 (3.9)
Forb Cover (%)	32.5 (7.74)	46.7 (9.70)	24.1 (3.98)	15.1 (5.09)	21.9 (15.7)
Cryptogamic Cover (%)	0 (3.93)	4.5 (0.87)	0.9 (1.20)	1.2 (0.57)	0.6 —
Maximum Height of Associate plants (cm)	60.6 (1.21)	65.9 (12.6)	65.2 (8.43)	55.8 (15.98)	67.5 (1.7)
Sample size	3	3	3	2	2

been summarized here by life form class (i.e., shrubs, grasses, forbs etc.). Since site floristics differed so greatly among regions, floristic differences were not considered useful for identifying commonalities and differences among sites. Structural differences however, were considered likely to significantly alter the environments occupied by the taxa. Average characteristics of vegetational structure in meadows occupied by these taxa are reported in Table 3. The numerical values support the concept that all of the buttercup taxa have evolved in meadow environments physiognomically similar to those the species now occupy. The meadows are wet enough to remain green throughout the growing season (personal observation), but not so wet as to exclude most species and to produce communities of low diversity (e.g., *Carex* meadows, Wilson 1969). Woody plants do poorly in meadows that support these buttercups, but isolated patches of shrubs and trees may occur on drier spots. A principal components diagram (not shown here) based on the vegetational data at the 13 sites showed little tendency for sites occupied by a particular taxon to cluster into a unique group well separated from sites occupied by other taxa.

Within each sampled meadow the buttercups showed patchy distribution. To identify local factors that might control distribution of the buttercups, vegetal characteristics of quadrats occupied by buttercups (data for all species pooled) were compared with characteristics of randomly chosen unoccupied sites within the same meadows. Discriminant analysis identified vegetal differences between occupied and unoccupied sites. Although average number of species per quadrat (0.25 m^2) was the only variable that differed significantly between occupied and unoccupied sites using simple t-tests (Table 4), discriminant analysis of the full data set clearly separated the

TABLE 4. COMPARISON OF MEAN VEGETATIVE DATA COLLECTED FROM SITES OCCUPIED OR UNOCCUPIED BY THE BUTTERCUP TAXA CONSIDERED IN THIS STUDY. Data for all taxa were pooled for this analysis.

	Occupied	Unoccupied
% cover	Mean (SE)	Mean (SE)
Grass	44.3 (4.9)	43.1 (4.62)
Forb	31.5 (4.37)	28.1 (4.38)
Litter	12.9 (4.16)	17.9 (5.13)
Soil	4.6 (1.71)	4.5 (1.37)
Rock	4.6 (3.91)	5.3 (3.32)
Cryptogam	1.6 (1.03)	0.6 (0.24)
Shrub	0.6 (0.25)	4.8 (2.60)
Avg. No. Species*	17.2 (1.00)	13.1 (0.80)
Avg. Height	63.0 (4.00)	67.4 (3.81)
Sample size	12	13

* Mean difference significant at 0.95 CI; all other differences between occupied and unoccupied sites are not statistically significant.

two groups (separation significant at the 0.003 probability level; Chi-Square value = 24.52). Discriminant function 1 yielded a classification percentage of 100 (i.e., occupied and unoccupied plots for all taxa were correctly placed) and a canonical correlation coefficient of over 0.85. Species richness was, as expected, shown to be the best variable for distinguishing occupied and unoccupied quadrats. Table 4 illustrates trends existing between sites occupied by buttercups and those that do not support those species in the same meadows. Microsites with greater grass, forb, and cryptogamic (moss) cover and with greater numbers of species are more likely to support buttercups, whereas sites with more litter and taller vegetation (especially woody plants) are less likely to support buttercups of this group.

Results of tissue chemistry analyses are summarized in Table 5. Unfortunately, only one tissue sample was available for the rare taxon *R. aestivalis.* However, that sample had elevated amounts of sulfur relative to values for other taxa. Sodium levels varied greatly among taxa. Relative placement of the five buttercups taxa along axes 1 and 2 of the principal components analysis of tissue chemistry is presented in Figure 3A. The first two principal components account for over 67% of the variation observed in the data set. With the exception of *R. acris,* the samples for each taxon lie close together in the figure and suggest rather similar tissue chemistry within a taxon. *Ranunculus occidentalis* is widely separated from other samples on the first axis, whereas the *R. aestivalis* sample is isolated from all other taxa on the second axis of Figure 3A. The two varieties of *R. acriformis* lie close together, suggesting considerable similarity in tissue chemistry. Figure 3B indicates the statistical

TABLE 5. MEAN VALUES FOR VARIOUS TISSUE CHEMISTRY VARIABLES FOR POPULATIONS OF EACH *RANUNCULUS* TAXON. Standard error for each mean is in parentheses. Abbreviations for taxa are as in Table 1. Elemental concentrations are reported as proportions of the oven dry tissue weights.

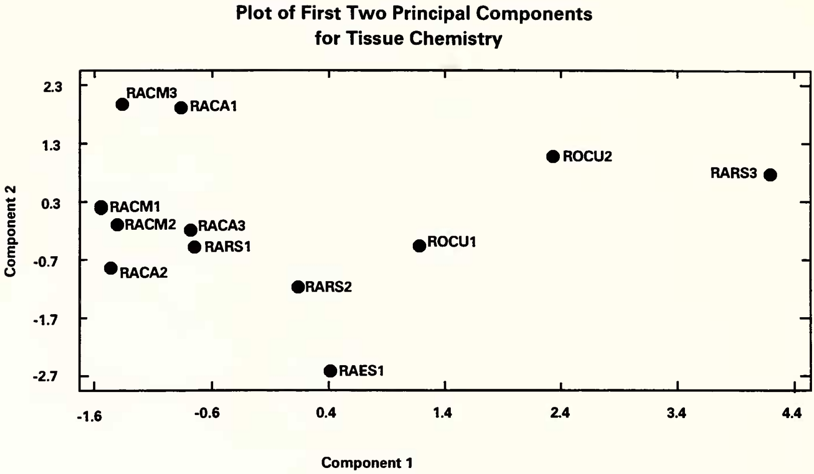
	Taxa				
Tissue component	RACA	RACM	RARS	ROCU	RAES
Phopshorus (%)	0.2	0.2	0.2	0.2	0.1
	(0.02)	(0.05)	(0.05)	(0.02)	—
Potassium (%)	2.1	2.5	2.2	1.9	2.0
	(0.17)	(0.12)	(0.39)	(0.08)	—
Calcium (%)	1.5	1.2	1.7	1.5	1.4
	(0.13)	(0.04)	(0.2)	(0.13)	—
Magnesium (%)	0.2	0.2	0.3	0.3	0.2
	(0.02)	(0.01)	(0.07)	(0.01)	—
Sulfur (%)	0.2	0.2	0.3	0.3	0.6
	(0.03)	(0.04)	(0.03)	(0.1)	—
Ash (%)	7.9	7.8	12.0	12.7	7.6
	(0.2)	(0.23)	(1.37)	(3.97)	—
Sodium (ppm)	59	51	1116	1899	915
	(23.1)	(12.5)	(432.0)	(338.0)	—
Sample size	3	3	3	2	1

weighting of the several chemical elements in tissue along the two principal component axes. Sodium, ash, and calcium values are well correlated with the first component (separation of *R. acriformis* and *R. occidentalis*), whereas sulfur content is strongly correlated with separation of *R. aestivalis* from other taxa on the second component axis. *Ranunculus aestivalis* tissue contained much more sulfur and less ash content than did tissue of the other taxa considered (Table 5).

DISCUSSION

All of the buttercup taxa considered in this paper occupy floristically complex natural communities, and moist, herbaceous habitats, suggesting that they have adapted to conditions found in such sites. Discriminant analysis identified vegetal characteristics that are strongly associated with occurrence of the species considered here. These taxa are not-likely to occupy microsites with tall vegetation and heavy accumulations of litter (Table 4). The species prefer soils that are moist enough to support significant growth of mosses and lichens but not so wet that a diversity of vascular plants is precluded. Microsites dominated by woody species are rarely occupied by buttercups in this complex.

Abiotic characteristics of habitats occupied by the autumn buttercup are shown to differ strongly from those associated with other buttercup taxa studied (Figs. 2A and 2B). The unique habitat char-



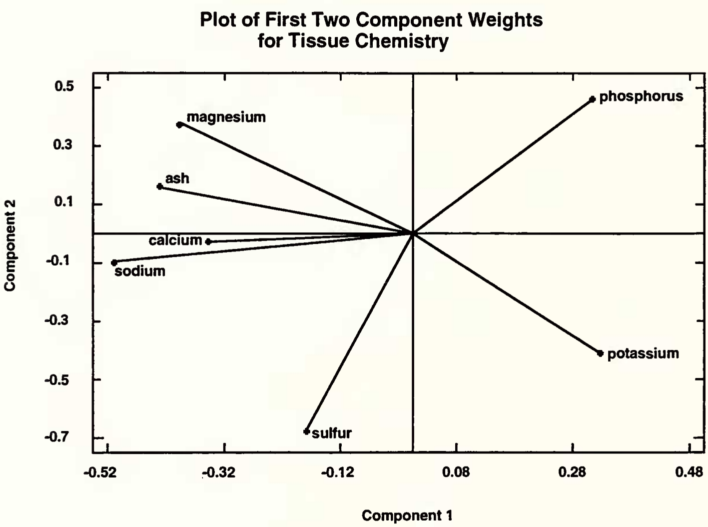


FIG. 3. A. Scattergram of the first two principal components of *Ranunculus* tissue analysis. Abbreviations for taxa as listed in Table 1. Populations are identified as numbers following the taxon. B. Plot of weighting vectors for content of selected elements in tissue of the buttercup populations shown in Figure 3A along the first two axes of the principal components analysis.

acteristics associated with *R. aestivalis* are reinforced by a geographical separation of at least 200 km (by air) from any other taxon in its generic subsection. Thus, both unique habitat features and disjunct distribution support recognition of the taxon as an independent species, which was earlier recommended on the basis of DNA markers (Van Buren et al. 1994). In respect to both abiotic characteristics of habitat and DNA markers, *R. aestivalis* is well separated from *R. acris* and the two varieties of *R. acriformis*. *Ranunculus occidentalis* also shows unique habitat characteristics.

Based on a single sample, tissue chemistry of the autumn buttercup differs considerably from tissue of our other buttercups (Figs. 3A and 3B). Sulfur content best explains the separation of this taxon from the others, but *R. aestivalis* tissue also contained relatively less ash than other taxa considered (Table 5).

Results of this study further justify elevation of *R. aestivalis* to species status, since the varieties of *R. acriformis* with which the species had originally been allied were not strongly differentiated by abiotic or biotic habitat variables or tissue chemistry. However, *R. aestivalis* was widely separated from those and other taxa in the complex by each of the foregoing analyses. Abiotic habitat characterization appears to be especially useful for distinguishing these taxa. *Ranunculus aestivalis* occurs in habitats where soil electrical conductivity, free carbonates, organic matter and depth values differ greatly from soils occupied by other taxa.

In all of the analyses performed in this study, *R. acris* populations differ widely from each other. Figures 2A and 3A both show wide separation of *R. acris* populations in the statistical space created using environmental or tissue chemical data. Populations of *R. acris* are as widely separated from each other as species in the analyses are from each other. A possible explanation for such disparate behavior is that each *R. acris* population may represent an independent introduction from different locations in Eurasia. Multiple introductions should result in a more diverse genotype for the species a condition which does appear to be represented in molecular data for the species (Van Buren et al. 1994)] and permit it to occupy very heterogeneous habitats.

Results from this study provide managers with useful information concerning the habitat of the endangered autumn buttercup. The species has diverged from close congeners and occupies meadow habitats that are more alkaline, more saline, and drier than those occupied by other taxa in the complex and the adventive taxon, *R. acris*. The authors especially draw attention to the apparent inability of the autumn buttercup (and other taxa in the complex as well) to persist where litter is allowed to accumulate in deep layers. Since the autumn buttercup disappeared from one site following termination of grazing and accumulation of deep litter mats, it may be necessary to reinstitute grazing during the dormant season (or resort to periodic early spring burns), to restore the species to sites historically grazed in the winter where it was initially discovered. The autumn buttercup differs from all other western North American congeners in respect to several DNA markers, kinds of habitats occupied, and tissue chemistry. It represents an accumulation of many unique qualities in the *R. occidentalis* complex and merits preservation on both genetic and aesthetic grounds.

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ANNOUNCEMENT

THE FUTURE OF ARID GRASSLANDS: IDENTIFYING ISSUES, FINDING SOLUTIONS

October 9–13, 1996 in Tucson Arizona

A solution-oriented conference for everyone interested in the future of grasslands in the American Southwest and Northern Mexico. This four-day conference will focus on understanding problems facing those grasslands and practical tools for grassland management, preservation and restoration. Attendees will be a mix of private and public land managers and owners, scientists, representatives of non-profit groups and concerned citizens. Two full days will be spent in the field, studying examples of grassland management in Southern Arizona. The other two days will include keynote speakers and panelists as well as small-group discussion and information sessions. The final day will focus on methods for preservation ranging from coordinated monitoring systems, land use and taxation tools to public involvement techniques.

Most of the speakers and panelists will be invited, but the planning committee welcomes abstracts for a few open sessions dealing with grasslands management, interrelationships between grasslands and humans or wildlife, and specific methods for preservation, especially success stories.

People are encouraged to submit abstracts for poster sessions which will be incorporated into the program featuring on-the-ground examples of problem solving to protect or restore grasslands. Both successful and unsuccessful examples are sought to illustrate what has and has not worked - and why.

The conference is organized by the Audubon Research Ranch and is cosponsored by numerous government agencies, educational institutions, and nonprofit groups.

For more information: Grasslands Conference, Tucson Audubon Society, 300 E. University # 128, Tucson AZ 85705, or the University of Arizona Water Resources Center at (520) 792-9591.